

Automatic identification of object-oriented variability implementations

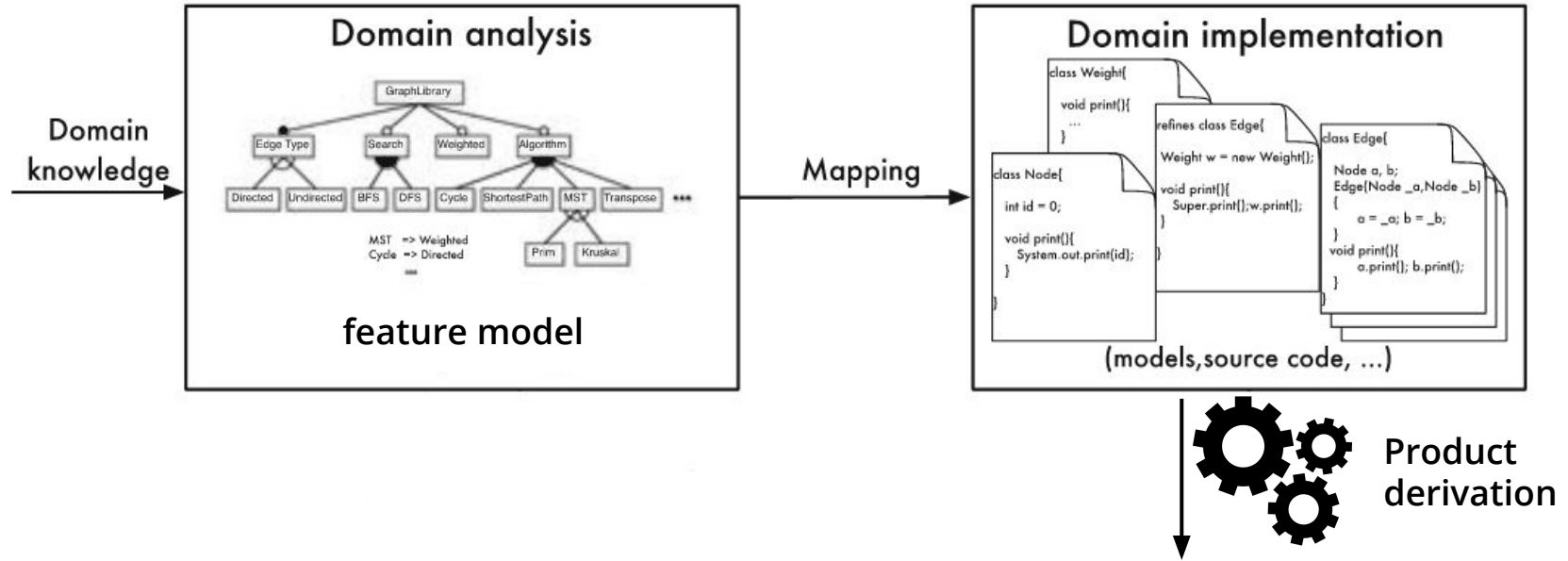
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Journée de travail du groupe Vélocité Logicielle
du GDR GPL

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Software Product Lines



Variability-Rich Systems with a Single Code Base



16.000 options managed
in 25M LoC [Acher2018]

#ifdef



ANDROID

24.000 different platforms in
2015 [Open2015]

Object-orientation

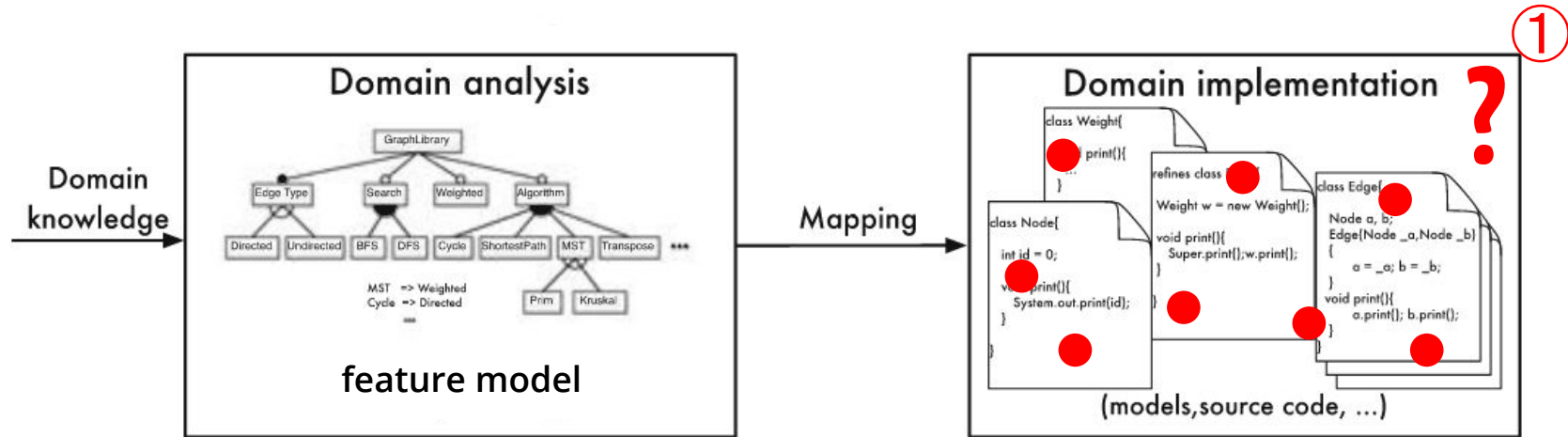


2.000+ options generating variants for
platforms, security levels... [Acher2018]

Object-orientation

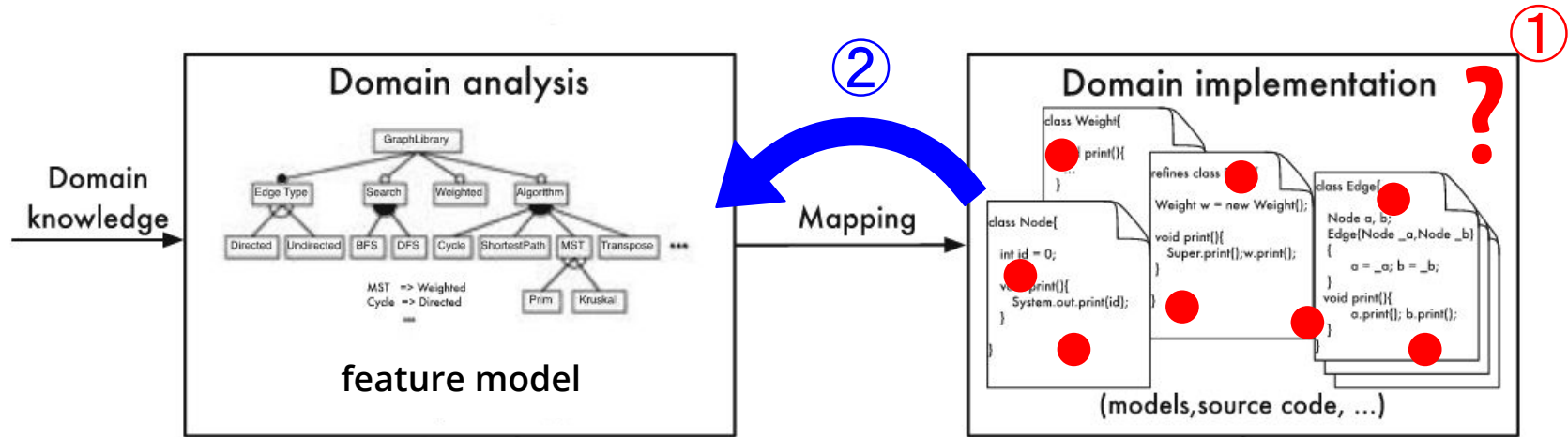
and many variability implementation techniques...

Problem 1: How to identify variability implementations in an existing OO codebase?



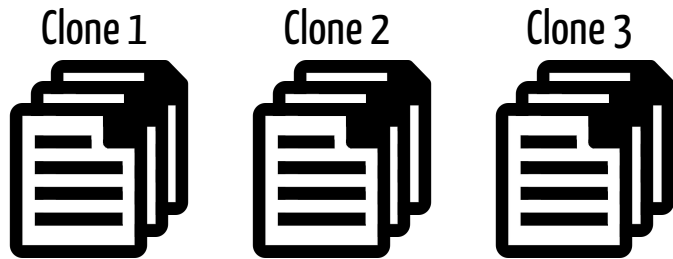
Problem 1: How to identify variability implementations in an existing OO codebase?

Problem 2: How to map these variability implementations to domain features?



State of the art on variability implementations detection

Context: [projects clones](#)

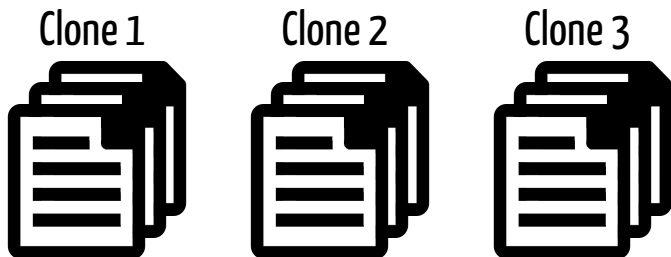


Detection method:

Comparison between clones and mapping with the domain features [Assunção2017]

State of the art on variability implementations detection

Context: [projects clones](#)

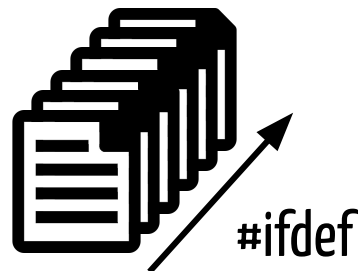


Detection method:

Comparison between clones and mapping with the domain features [Assunção2017]

Context: unique codebase and [preprocessing directives](#)

`#ifdef` → variant



Detection method:

Determining the consistency of directives [Liebig2010]

State of the art on variability implementations detection

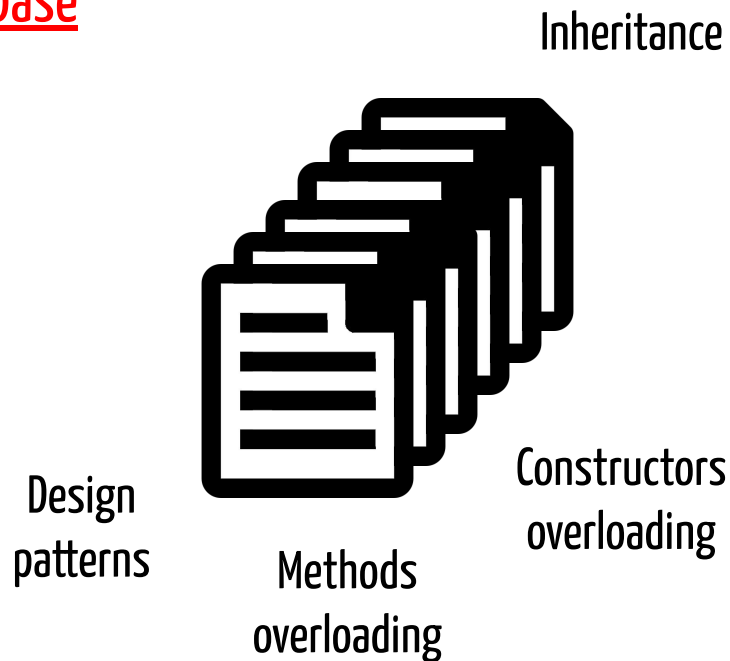
Our context: large and unique object-oriented codebase

- Several implementation mechanisms
- Variability buried in the code (variation points)

Detection method:

Currently no method

[Lozano2011], [Metzger2014], [Těrnava2017]



Variation points and variants

```
1 | public abstract class Shape {
2 |     public abstract double area();
3 |     public abstract double perimeter(); /*...*/
4 | }
5 |
6 | public class Circle extends Shape {
7 |     private final double radius;
8 |     // Constructor omitted
9 |     public double area() {
10 |         return Math.PI * Math.pow(radius, 2);
11 |     }
12 |     public double perimeter() {
13 |         return 2 * Math.PI * radius;
14 |     }
15 | }
```

```
15 | public class Rectangle extends Shape {
16 |     private final double width, length;
17 |     // Constructor omitted
18 |     public double area() {
19 |         return width * length;
20 |     }
21 |     public double perimeter() {
22 |         return 2 * (width + length);
23 |     }
24 |     public void draw(int x, int y) {
25 |         // rectangle at (x, y, width, length)
26 |     }
27 |     public void draw(Point p) {
28 |         // rectangle at (p.x, p.y, width, length)
29 |     }
30 | }
```

Variation points and variants

```
1 | public abstract class Shape {
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vp_shape

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v_rectangle

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vp_draw

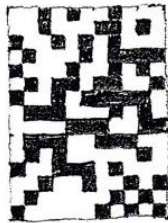
The theory of centres and the notion of symmetry [Alexander2002]

Centre: a field of organized force in an object or part of an object which makes that object or part exhibit centrality.

A **centre** is commonly formed by a **local symmetry**.

⇒ The centre is the common part of the symmetric variants.

Random
→ hard to describe

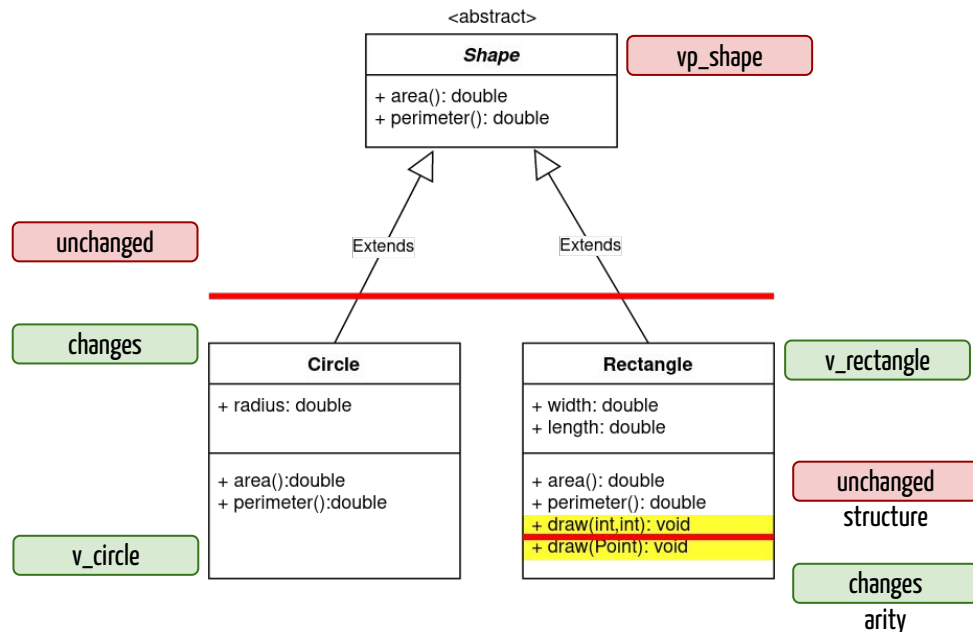


Ordered around a
centre of symmetry
→ easy to describe

Use of symmetries to detect variability implementations?

Intuition:

- Presence of **symmetries in object-oriented codebases** [Coplien2019] inspired from the theory of centres
- Symmetries present in **mechanisms implementing variability**



Identifying variation points with variants

Variability implementation technique



local symmetry

- variation point (commonality)
- variant (variability)



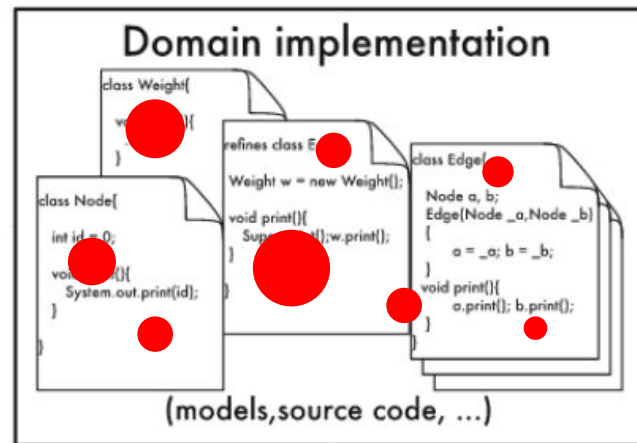
unchanged



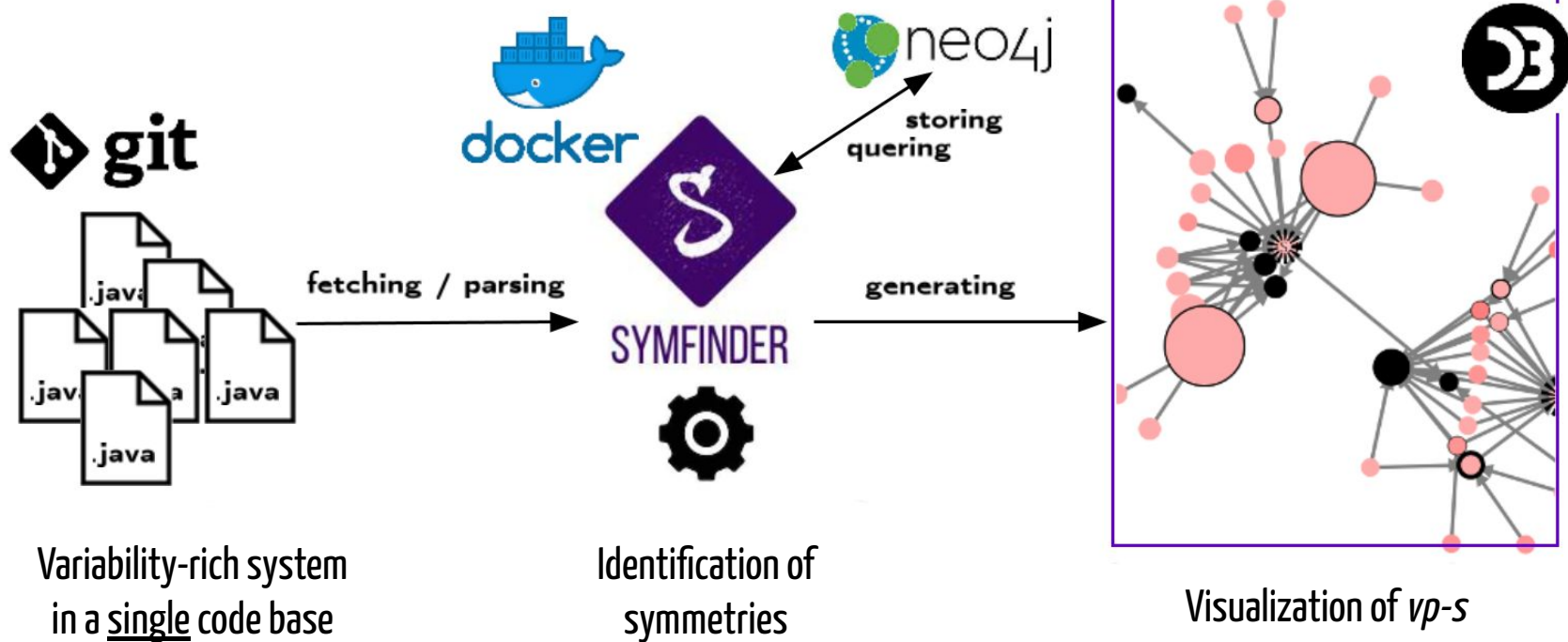
changes

Identification through local symmetries in core assets

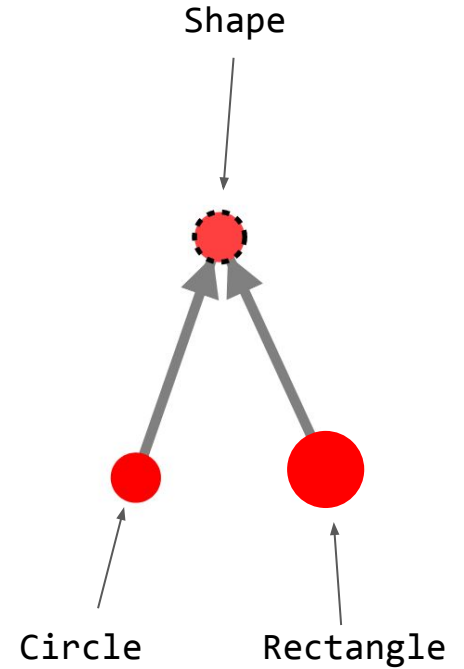
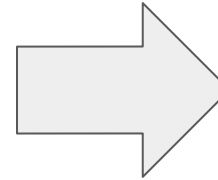
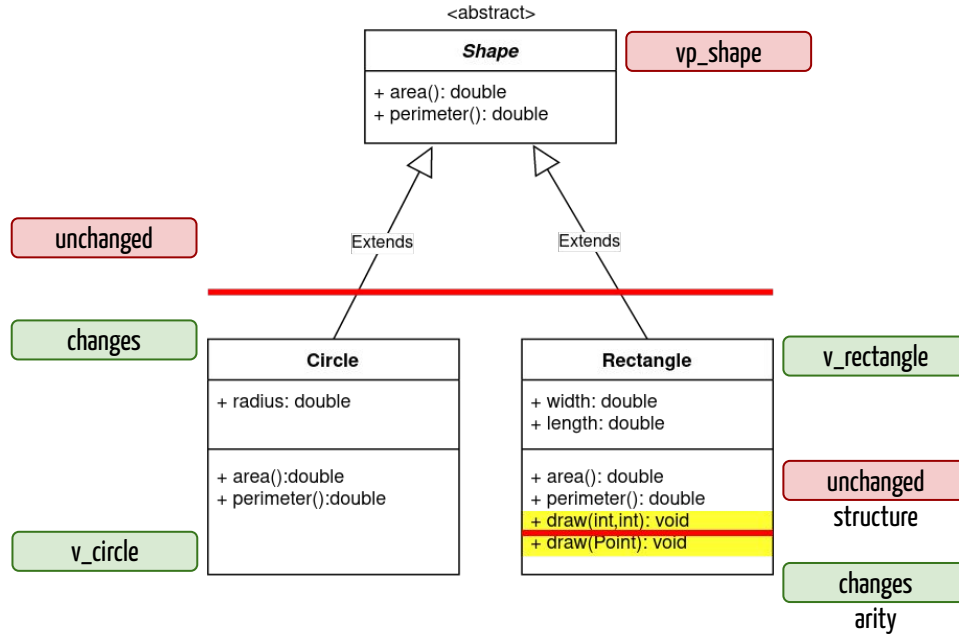
High density of symmetries → variability intense places



symfinder

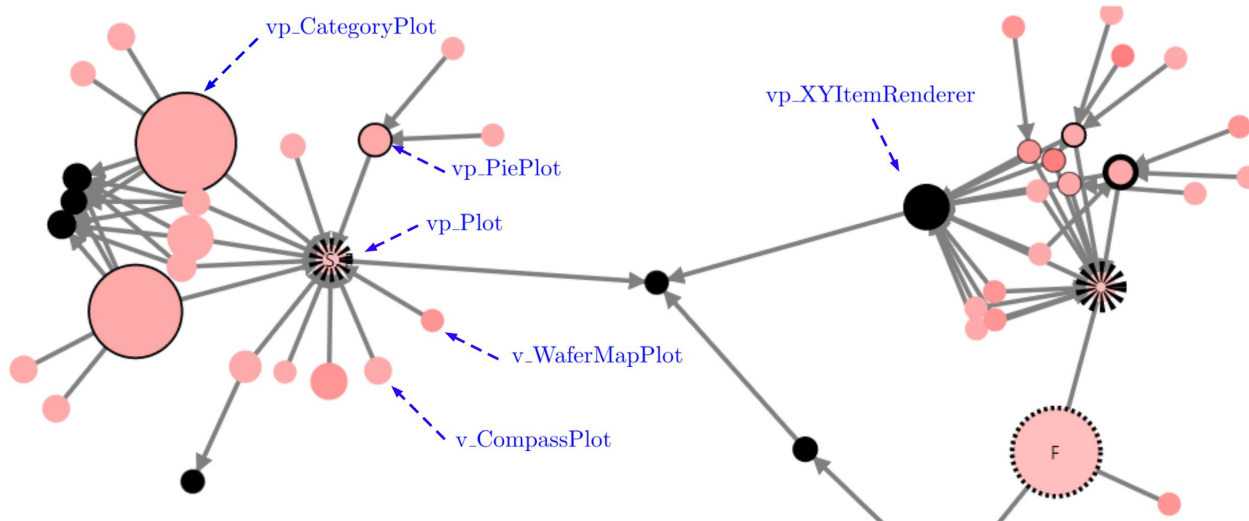
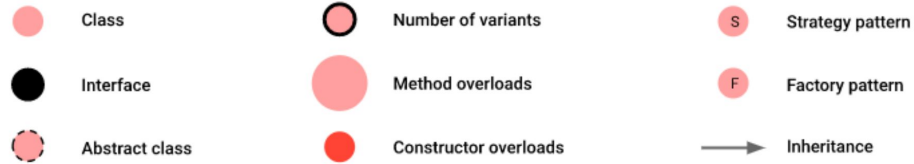


Visualizing a small example

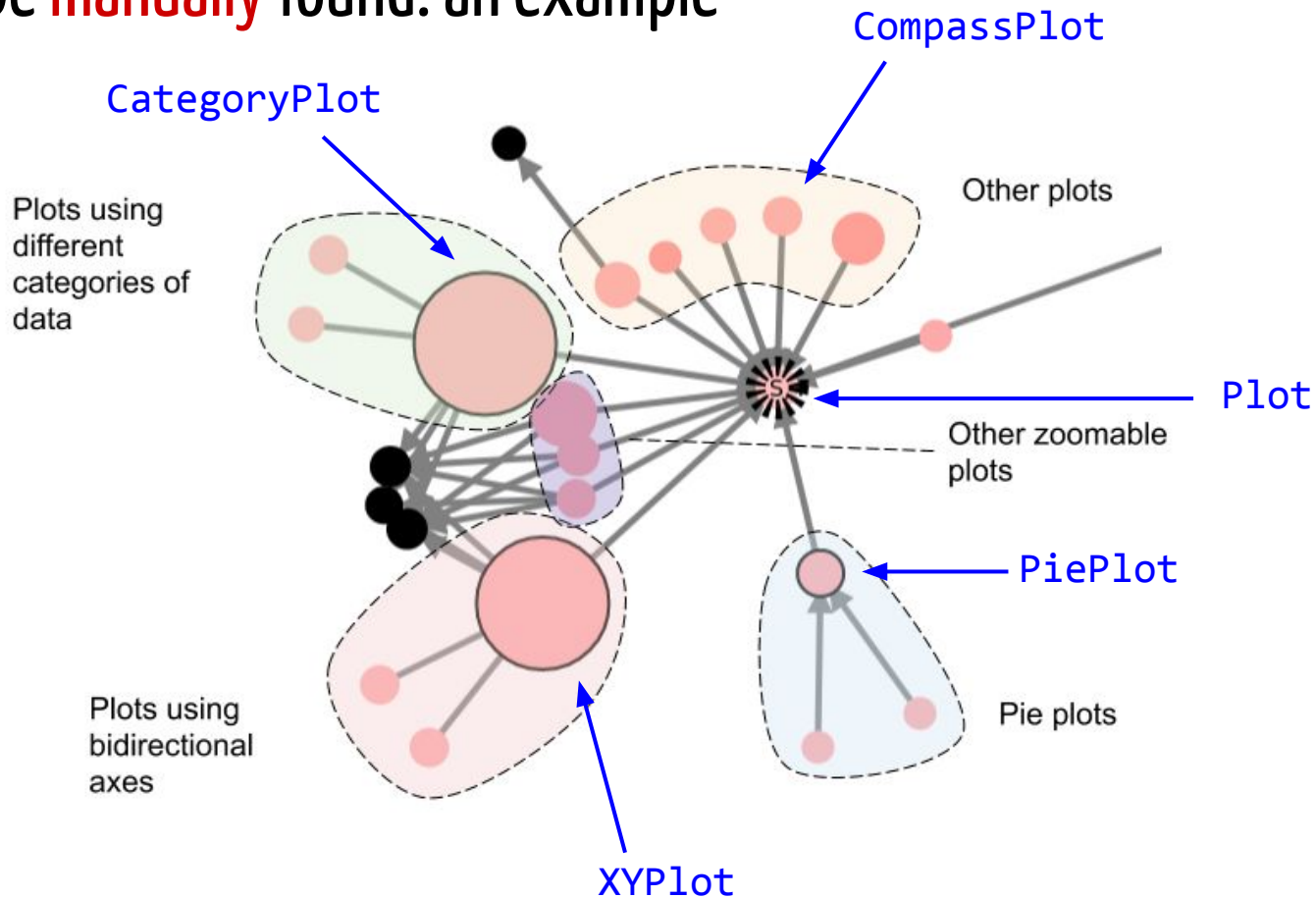


Automatic visualization of *vp-s* with variants

Symfinder Show project information Hide legend jfreechart-v1.5.0 generated by symfinder version 549c



What can be manually found: an example



Subject system	Analysed LoC	#vp-s	#variants
Java AWT	69,974	1,221	1,808
Apache CXF 3.2.7	48,655	7,468	9,201
JUnit 4.12	9,317	253	319
Apache Maven 3.6.0	105,342	1,443	1,393
JHipster 2.0.28	2,535	140	115
JFreeChart 1.5.0	94,384	1,415	2,103
JavaGeom	32,755	720	919
ArgoUML	178,906	2,451	3,079

Synthesis

Goals reached:

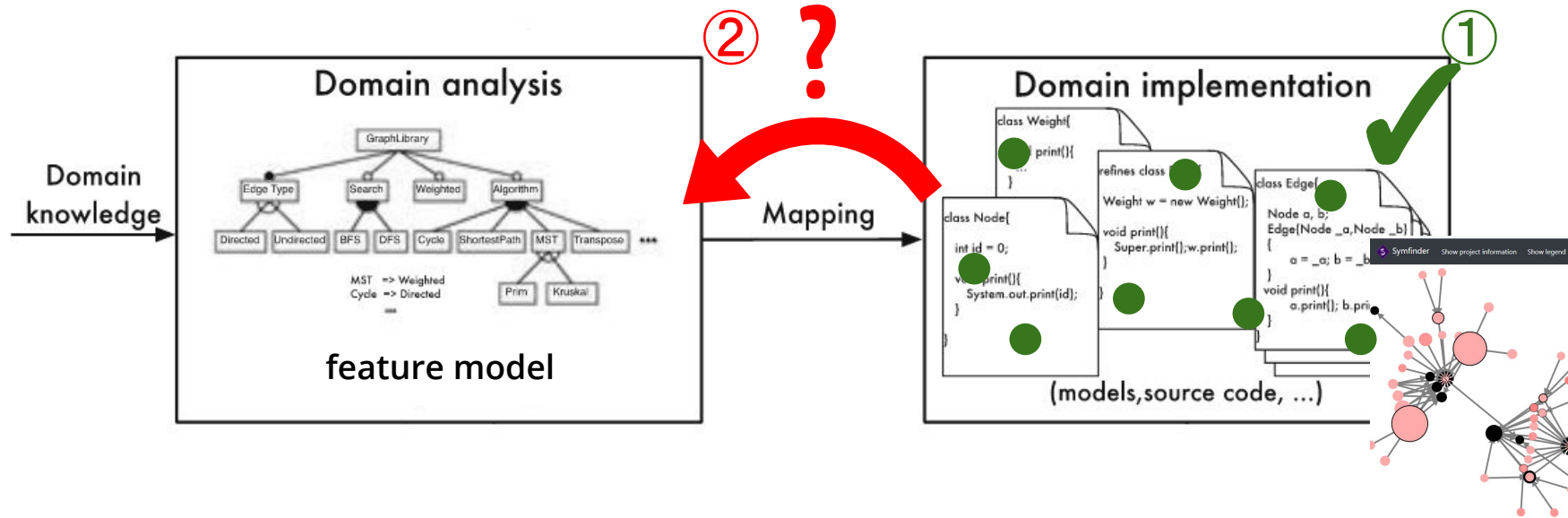
- ✓ Definition of vp-s with variants in implementation relying on the notion of symmetry
- ✓ Toolchain for automatic identification
- ✓ Some vp-s and variants can be visually mapped to domain features

Next step:

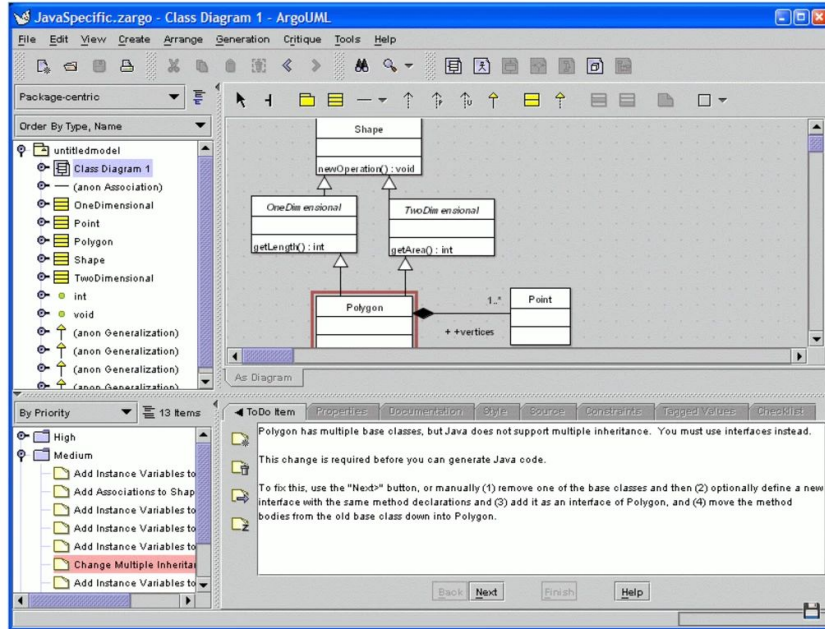
- Are the identified vp-s with variants valuable?
- Need to measure the quality of our identification method.

Problem 1: How to identify variability implementations in an existing OO codebase?

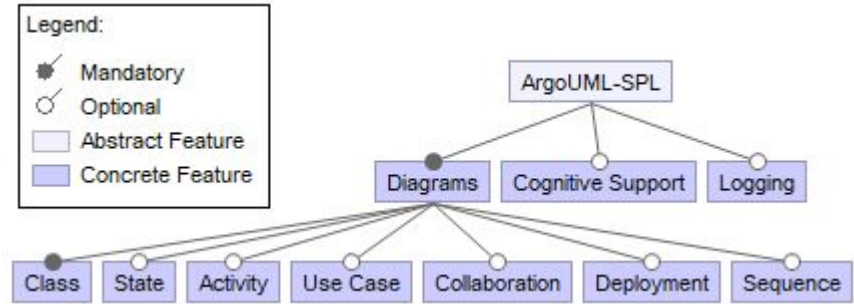
Problem 2: How to map these variability implementations to domain features?



ArgoUML-SPL [Couto2011]

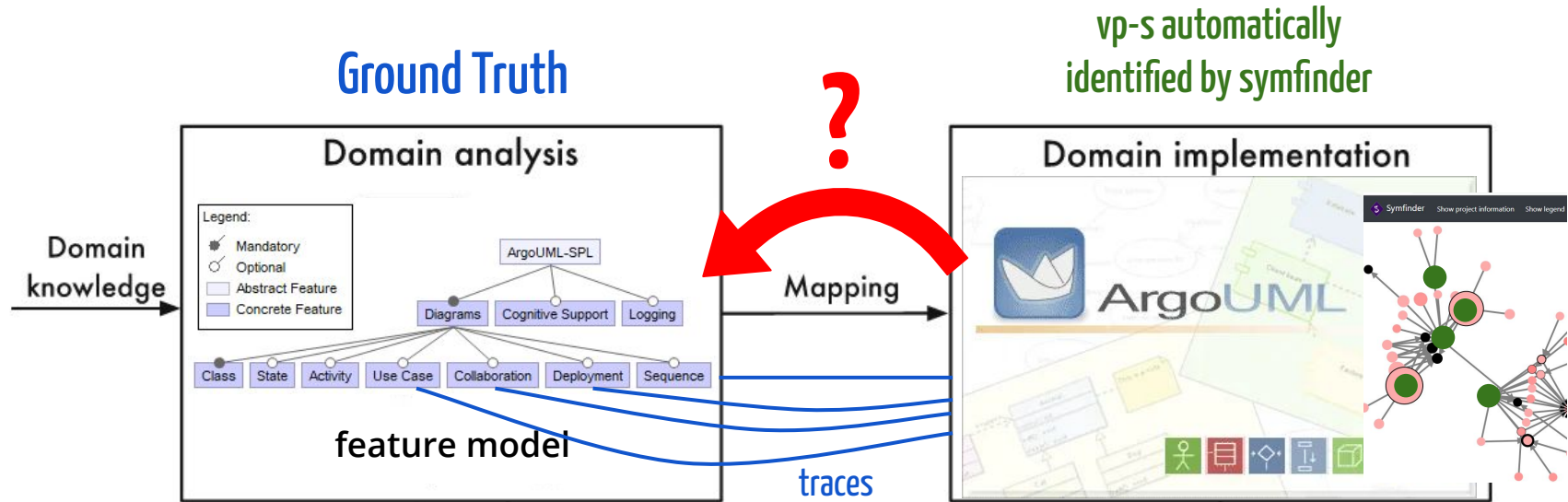


ArgoUML editor



Feature model of ArgoUML-SPL

Question: Are the identified *vp-s* from ArgoUML relevant for a feature mapping?



Example on ArgoUML-SPL

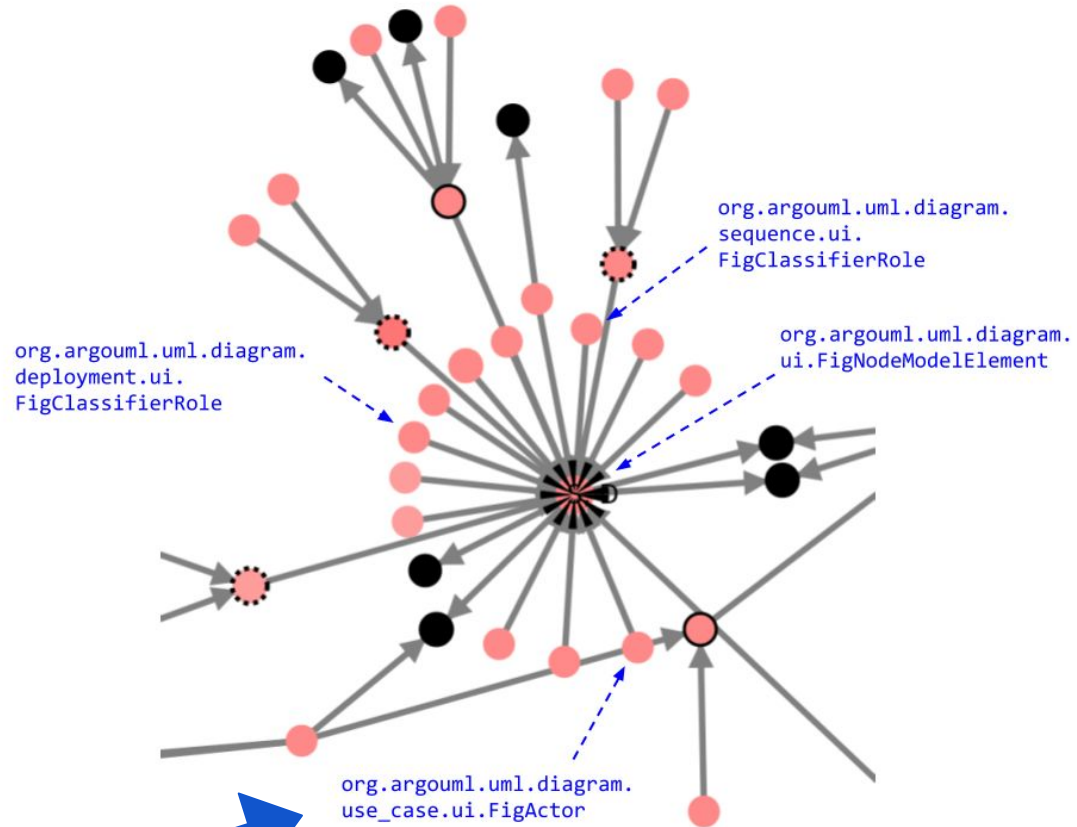
Feature: Sequence

```
##if defined(SEQUENCEDIAGRAM)  
##@$LPS-SEQUENCEDIAGRAM:GranularityType:Package  
public class FigClassifierRole extends FigNodeModelElement
```

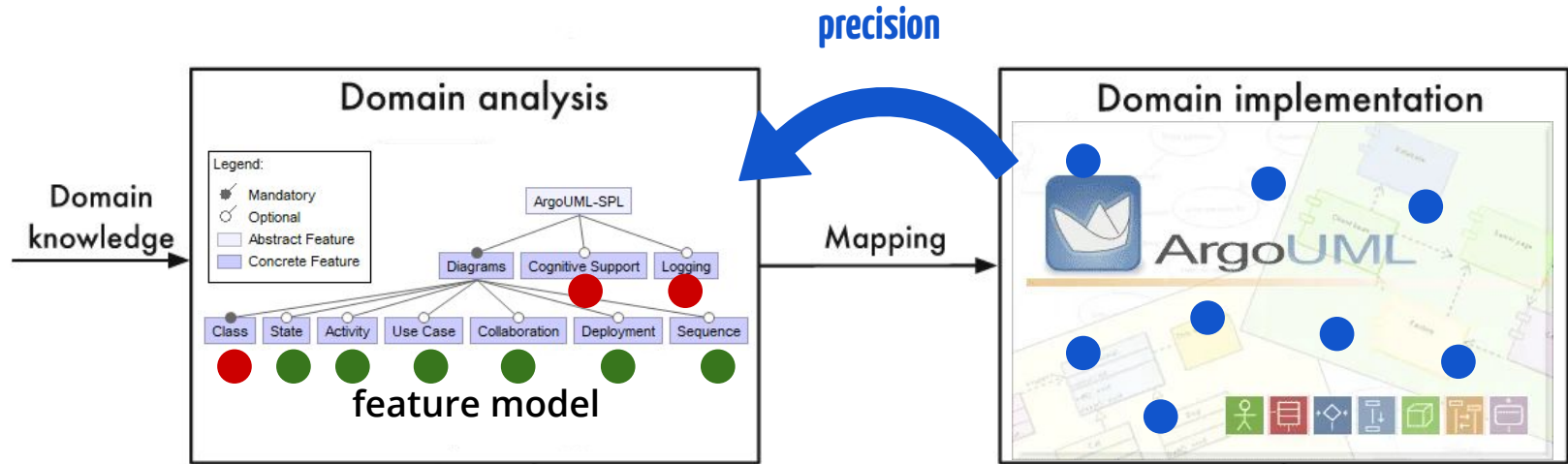


Feature: Use Case

```
##if defined(USECASEDIAGRAM)  
##@$LPS-USECASEDIAGRAM:GranularityType:Package  
public class FigActor extends FigNodeModelElement
```



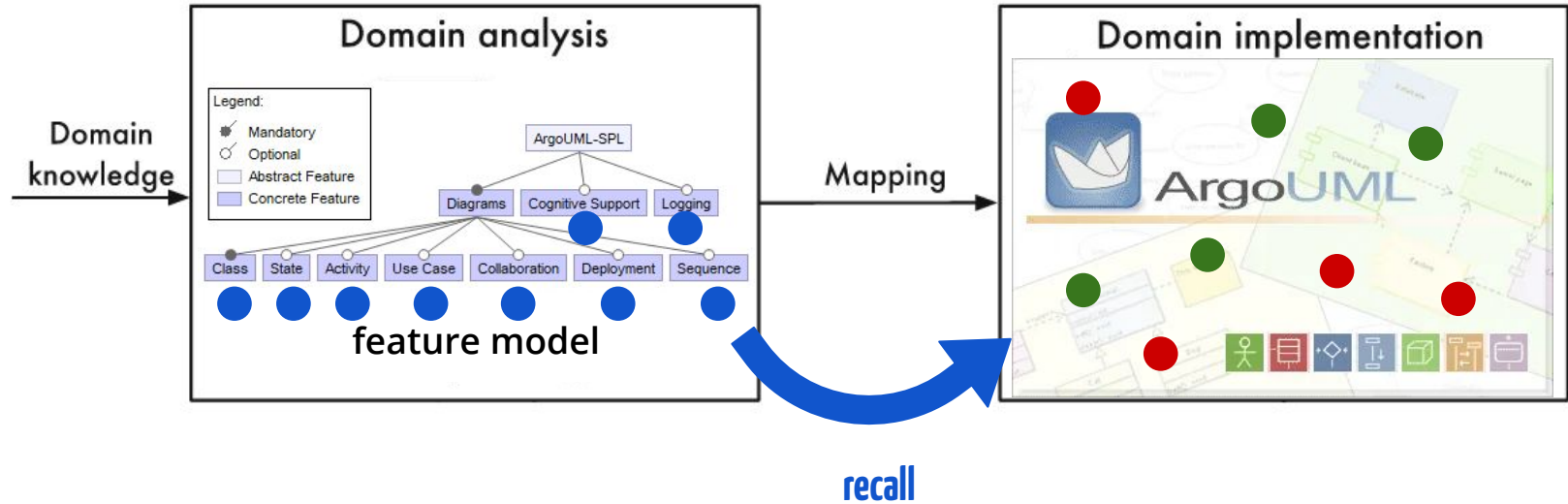
Relevance of the *vp-s*



Precision:

Percentage of identified *vp-s* and variants that could be mapped to domain features

Relevance of the *vp-s*



Recall:

Percentage of features' traces that could be mapped to identified *vp-s* and variants

Relevance of the vp -s

Calculating precision

$$precision = \frac{TP}{TP + FP} = \frac{|T_{gt} \cap I_{vp-v}|}{|I_{vp-v}|} = \frac{593}{1560} = 38\%$$

Low precision was **expected**:

- coarse grain features based on superficial domain knowledge
- not all identified places with a symmetry are related to variability

⇒ need for a more precise identification

Relevance of the vp -s

Calculating recall

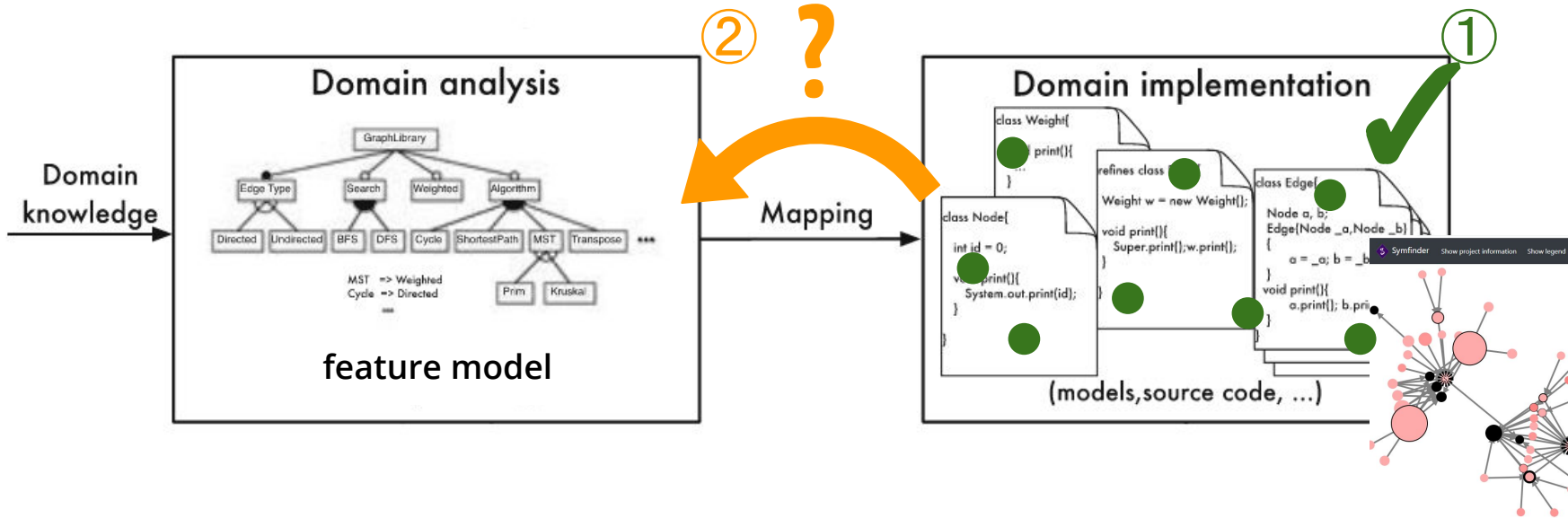
$$recall = \frac{TP}{TP + FN} = \frac{|T_{gt} \cap I_{vp-v}|}{|T_{gt}|} = \frac{593}{712} = 83\%$$

The missing 17% of traces are **not variability related**:

- initialization classes
- external libraries

Problem 1: How to identify variability implementations in an existing OO codebase?

Problem 2: How to map these variability implementations to domain features?



Future work

- Formal definition of density to increase the precision
- Map variation points and variant to preprocessor directives
- Analyse multi-components systems and systems of systems
- Ongoing experiment on Sat4j's codebase with Daniel Le Berre



Automatic identification of object-oriented variability implementations

Johann Mortara – Philippe Collet

- ✓ Definition of vp-s in implementation relying on the notion of symmetry
 - ✓ Automatic identification and visualization of vp-s and variants, exhibiting zones of high density of symmetries
 - ✓ First mapping shows that some identified vp-s with variants are relevant for feature mapping
- ⇒ Need for a more precise detection method

References

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